Problem Statement

Buildings contribute almost 30% of global emissions (Ürge-Vorsatz, 2012)

- Potential for significant energy and emissions reductions

Building Form - Balance

- Energy Consumption
- Energy Generation
- Function

Source: Global Alliance for Buildings and Construction, 2016
Aims

Investigate the impact of changes in building form upon energy use intensity and energy generation intensity

Compare energy use and generation intensity results from Building Performance Simulation in OpenStudio
Simulation 1: Constant total floorspace (10,000 m\(^2\)), square floorplan. Changing the number of floors
Simulation 2: Constant total floorspace (10,000 m²) and 10 floors. Changing length to width ratio
Simulation 3: Changing number of 1,000m² square floors
## Template Building – Fixed Variables

<table>
<thead>
<tr>
<th></th>
<th>Sydney</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Sydney</td>
</tr>
<tr>
<td><strong>Lighting Power Density</strong></td>
<td>6.4 W/m²</td>
</tr>
<tr>
<td><strong>Equipment Power Density</strong></td>
<td>10.6 W/m²</td>
</tr>
<tr>
<td><strong>% Solar Usable Surface Area</strong></td>
<td>75%</td>
</tr>
<tr>
<td><strong>Solar Efficiency</strong></td>
<td>20%</td>
</tr>
<tr>
<td><strong>Roof R-Value</strong></td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Wall R-Value</strong></td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Window U-Value</strong></td>
<td>3.7</td>
</tr>
<tr>
<td><strong>HVAC System</strong></td>
<td>VAV with PFP Boxes and Electric Reheat (Chiller COP 5.5)</td>
</tr>
<tr>
<td><strong>Window to Wall Ratio</strong></td>
<td>40%</td>
</tr>
<tr>
<td><strong>Floor-to-Ceiling Height</strong></td>
<td>3.6 m</td>
</tr>
</tbody>
</table>
Simulation 1 – Energy Use Intensity/Energy Generation Intensity vs Number of Floors

EUI not significantly affected (~5% change)

EGI significant shifts (~500% increase for building with larger roof surface area)
Simulation 2 - Energy Use Intensity/Energy Generation Intensity vs Length: Width Ratio

EGI significant shifts (~30% increase as façade surface area increases)
Simulation 3 - Energy Use Intensity/Energy Generation Intensity vs Total Floorspace

EGI significant shifts (~500% increase for building where roofspace becomes much smaller portion of PV/BIPV envelope)
Results – HVAC Energy Use Intensity vs Compactness Factor (Volume: Surface Area)

HVAC EUI much more influenced by building form
Results – Generation Potential vs Compactness Factor (Volume: Surface Area)

- Energy Generation Intensity (kWh/m² pa)
- Volume: Surface Area Ratio
- # Floors
- Total Floorspace
- Length:Width Ratio

EGI inversely proportional to building compactness
Key Findings

BUILDING FORM IMPACTS HVAC EUI – 36% REDUCTIONS POSSIBLE

GENERATION POTENTIAL GREATLY INFLUENCED BY CHANGES IN BUILDING FORM FOR BIPV SURFACE AREA (FIVEFOLD INCREASE)
Implications and Future Work

Balancing generation potential against building form (keep HVAC EUI low) against functionality

Results do not account for surrounding buildings: tested required against more realistic shading scenarios

BIPV solutions not costed
References